EFFECT OF FURROW LENGTH AND METHODS OF APPLYING IRRIGATION ON COTTON YIELD AND WATER USE EFFICIENCY
Meleha, M.E.
Center, Egypt.

ABSTRACT
A field experiment was conducted in 1997 growing season, at El-Karda Water Requirements Research Station, Kafr El-Sheikh Governorate, to evaluate the furrow lengths and method of applying irrigation on cotton seed yield and water use efficiency. Five treatments were arranged in split-plot design. Three of them for furrow lengths which were 40, 60 and 80 meters and the others for methods of applying irrigation water (with siphon-without siphon).

The obtained results showed that the cotton seed yield increased with decreasing furrow length and using siphon tube-in the applied irrigation water. There is no significant difference in values of water consumptive use among treatments. The treatment of 40 meters furrow length with using siphon tube recorded the highest values of irrigation application efficiency, crop water use efficiency and field water use efficiency. Data revealed also that the use of siphon tubes method for irrigation obtained the advantage of controlling water given to the field.

INTRODUCTION
Irrigation is generally defined as the application of water to soil for the purpose of supplying the moisture essential for plant growth. Efficient use of irrigation water is an obligation of each user. However, efficiency of use will vary from locality to another. In areas where water is scarce and costly, available water should be used carefully.

Israelsen & Hansen (1962) stated that irrigation water is applied to land by three general method; namely, (a) Surface by flooding (b) subsurface or with furrow; in which the surface is wetted little if only, and (c) Sprinkling in which the soil surface is wetted much as it is by rainfall. Criddle et al. (1956) showed that the maximum allowable length of run is the longest distance in which the maximum allowable furrow stream can affect nearly uniform distribution of water in the soil. He added that the higher efficiencies might be obtained if the fields are shorter than the maximum allowable. But, if the fields are only slightly longer than the maximum allowable, a lower irrigation efficiency might be preferable to cut the furrow length in two. Salam et al. (1972) estimated the maximum allowable length of furrow that does not cause any excessive erosion using siphon tube method under different soils from the following equation:

\[
L = \frac{4 \times 7.6 \times 10^{-4} \times W^{10/3}}{cd \times TT \times d^2 \times \sqrt{2gh} \times 2340} \times \frac{1}{K}
\]
Meleha, M.E.

Where:
L = Maximum allowable length of the furrow.
W = Furrow spacing.
Cd = Discharge coefficient of siphon tube.
d = Inside diameter of siphon tube.
h = Head of siphon tube.
TT = Total time required to irrigation.
g = Gravity acceleration.
K = Permeability Coefficient.

Salam et al. (1973) stated that adequate control and management of irrigation water require methods to evaluate irrigation practices from the time at which water leaves the point of diversion until it is utilized by the plants. The best irrigation device is that which minimizes the waste of water as much as possible. The use of siphon tubes method for irrigation has the advantage of controlling water given to the field. El – Mowelhi et al. (1990) and Saied (1992) pointed out that the water requirement of cotton was from 3200m3 to 3900m3, the water consumptive use were from 52.89 cm to 58.42 cm and the water application efficiencies was from 63 to 74% according to the land leveling method and irrigation water discharge. Eid & Hosny (1995) pointed out that optimum water requirement for cotton will range between 94.5 and 115.5 cm in Egypt, depending on regional climate.

The aim of this work is to study the effect of furrow length and methods of applying irrigation water on cotton seed yield, water consumptive use and water use efficiency.

MATERIALS AND METHODS

This study was conducted at El-Karada Farm (Kafer El-Sheikh) governorate in the summer season of 1997, to study the effect of furrow length and methods of field irrigation on cotton seed yield, its water consumptive use and water use efficiency.

Treatments:
A : Furrow Lengths:
A1 : Furrow length of 40m,
A2 : Furrow length of 60 m and,
A3 : Furrow length of 80 m.

B: Methods of field irrigation
B1: Using siphon tubes ;

A split plot design with four replicates was used. The main plots were subjected to the furrow length treatments and the Sub-plots were to the methods of field irrigation. Cotton (Giza 86) was planted on March 30 and harvested on October 20, 1997 and all the experimental treatments received
the same agricultural practices as usual in this area. The analysis of the field experiment soil was done according to Jackson, (1958) and Black (1965) which indicated that the soil texture was clayey, ECe 2.18 dSm-1 in saturated paste extract, pH 8.1 in 1:2.5 soil water suspension. The hydraulic characteristics, Field capacity 38.67%, wilting point 21.01% and bulk density 1.15 g/cm³ (average of 0–60 cm).

Water relations: The amount of applied irrigation water was measured by a weir using this equation:

\[ Q = CLH^{3/2} \]

Where
- Q = The discharge in cubic meters per second
- C = An empirical coefficient that must be determined from discharge measurements.
- L = The length of the crest in meters.
- H = The head in meters.

The irrigation water was applied to the furrows by siphon (Inside diameter was 4cm). Water consumptive use was calculated according to the following equation:

\[ CU = \sum_{i=1}^{N} \frac{\theta_2 - \theta_1}{100} \times Bd \times \frac{60}{100} \times 4200 \]

Where
- CU = Water consumptive use, m³/Fed.,
- N = Number of irrigations,
- \( \theta_2 \) = Soil moisture content % after irrigation,
- \( \theta_1 \) = Soil moisture content % before irrigation and
- Bd = Soil bulk density (g/cm³).

Irrigation efficiency:

Irrigation application efficiency (Ea):

Values of irrigation application efficiency (Ea) for each treatment was obtained by dividing the irrigation water stored on the applied irrigation water (Downy, 1970);

\[ \frac{Ws \times 100}{Wd} \]

Where:
- Ea = Water application efficiency.
- Ws = Water stored.
- Wd = Water delivered to the field plot.

Irrigation distribution efficiency:

It is express the uniformity of the distribution of irrigation water through the root zone.
Meleha, M.E.

\[
\frac{Y}{D} = \frac{100 (1 - \text{-----})}{\text{-----}} \quad \text{(Michael, 1978)}.
\]

Where
\[
Ed = \text{Water distribution efficiency, \%}.
\]
\[
Y = \text{Average numerical absolute deviation in depth of water stored}.
\]
\[
D = \text{Average depth of water stored during the irrigation}.
\]

3-Crop water use and utilization efficiency

Crop water use efficiency is the weight of marketable crops produced per the volume unit of water consumed by plants or the evapotranspiration quantity (Abd El-Rasool et al., 1971). The utilization efficiency is the weight of marketable crops produced per the volume unit of applied irrigation water expressed as cubic meters of water (Michael, 1978).

RESULTS AND DISCUSSION

1-Effect of furrow length and method of applying irrigation water on cotton seed yield:

Means of cotton seed yield in Kentar per feddan as influenced by the furrow length and method of applying irrigation water are presented in Table (1). Data revealed that yield of cotton seed was not affected significantly by furrow length treatments. The highest values was obtained from treatment A3 (5.95 Kentar/Fed). followed by treatment A2 (5.88 Kentar/Fed.), while the minimum cotton seed yield was obtained from treatment A1. Also it was noticed that the method of applying irrigation water significantly affected cotton seed yield. Treatment B2 recorded the highest value 6.3(Kentar/Fed.)While treatment B2 recorded the lowest values (5.44 Kentar/Fed). The interaction effect of Ax.B. was not significant.

Table (1): The average values of cotton seed yield (kentar/fed.) as affected by furrow length and method field irrigation in 1997 season.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Cotton seed yield (Kentar/fed.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furrow length, m</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>6.01</td>
</tr>
<tr>
<td>60</td>
<td>5.88</td>
</tr>
<tr>
<td>80</td>
<td>5.73</td>
</tr>
<tr>
<td>Mean</td>
<td>5.87</td>
</tr>
<tr>
<td>F. test</td>
<td>NS</td>
</tr>
<tr>
<td>L.S.D. 5%</td>
<td>-</td>
</tr>
<tr>
<td>L.S.D. 1%</td>
<td>-</td>
</tr>
<tr>
<td>Method of Field Irrigation</td>
<td></td>
</tr>
<tr>
<td>Used siphon tube</td>
<td>6.30</td>
</tr>
<tr>
<td>Without siphon tube</td>
<td>5.44</td>
</tr>
<tr>
<td>Mean</td>
<td>5.87</td>
</tr>
<tr>
<td>F. test</td>
<td>**</td>
</tr>
<tr>
<td>L.S.D. 5%</td>
<td>0.14</td>
</tr>
<tr>
<td>L.S.D. 1%</td>
<td>0.33</td>
</tr>
<tr>
<td>Interaction A x B</td>
<td>NS</td>
</tr>
</tbody>
</table>

** and NS means significant at 1% and not significant, respectively.
2- Water consumptive use

The seasonal water consumptive use by cotton plants as influenced by Furrow length and method of applied irrigation water is shown in Table (2). The furrow length 80 m (A 3) recorded the highest values of cotton consumptive use (63.82 cm), while the lowest values was obtained from furrow length 40 m treatment (63.34 cm). On the other hand, the methods of applied irrigation water without using siphon tube consumed more water in comparison with using siphon tube.

Table (2): Seasonal water consumptive use for cotton plants as affected by different treatments in 1997 season.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Water Consumptive use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furrow Length , m</td>
<td>Method of Applied irrigation</td>
</tr>
<tr>
<td>40</td>
<td>With Siphon</td>
</tr>
<tr>
<td></td>
<td>Without siphon</td>
</tr>
<tr>
<td>60</td>
<td>With Siphon</td>
</tr>
<tr>
<td></td>
<td>Without siphon</td>
</tr>
<tr>
<td>80</td>
<td>With Siphon</td>
</tr>
<tr>
<td></td>
<td>Without siphon</td>
</tr>
</tbody>
</table>

3- Total amount of irrigation water

The amounts of applied irrigation water delivered to different treatments are given in Table (3). It is clear from data obtained that the water requirements for cotton plants range between 3500 and 3638 m³/Feddan. The highest value was recorded from treatment A3, while the lowest value is obtained from A1. On the other side, the siphon tube can save more water than without using siphon. The average value of saved water was 43.33 m³/Fed.

Table (3): Number of irrigations and amounts of irrigation water delivered to the different treatments.

<table>
<thead>
<tr>
<th>No. of Irrigations</th>
<th>Length of Furrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planting</td>
<td>40 m</td>
</tr>
<tr>
<td></td>
<td>60 m</td>
</tr>
<tr>
<td></td>
<td>80 m</td>
</tr>
<tr>
<td></td>
<td>With Siphon, m³/fed.</td>
</tr>
<tr>
<td></td>
<td>670</td>
</tr>
<tr>
<td>1</td>
<td>305</td>
</tr>
<tr>
<td></td>
<td>404</td>
</tr>
<tr>
<td>2</td>
<td>430</td>
</tr>
<tr>
<td>3</td>
<td>449</td>
</tr>
<tr>
<td>4</td>
<td>419</td>
</tr>
<tr>
<td>5</td>
<td>413</td>
</tr>
<tr>
<td>6</td>
<td>410</td>
</tr>
<tr>
<td>7</td>
<td>3500</td>
</tr>
<tr>
<td>Water saving m³/Fed</td>
<td>39</td>
</tr>
</tbody>
</table>
Meleha, M.E.

4- Soil moisture extraction pattern:
Data of soil moisture extraction percentage in the upper 60cm of soil are presented in Table (4).
Data revealed that the most of the water consumed by cotton roots is removed from the soil surface layer. The highest Percentage of the moisture uptake by cotton plant roots is occurred in the surface 15cm depth of the soil profile, it ranges between 43.49 and 45.06%. Less water is extracted from the successive depths. It can be concluded that about 69.14% of the stored water which used by cotton plants is obtained from the surface soil layer (30cm) and about 30.86% from the sub-surface layer (30-60cm). These conclusions are similar to those obtained by Karev (1974), Taylor and Klipper (1974), and Saied (1992). They found that 70-90% of cotton roots are found in the surface 40-50cm of soil profile.

Table (4): Mean values of soil moisture extracted (percentage) by cotton plants from different layers as affected by different treatments in 1997 season.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Soil depth (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furrow Length, m</td>
<td>Methods of Applied irrigation</td>
</tr>
<tr>
<td>40</td>
<td>With Siphon</td>
</tr>
<tr>
<td></td>
<td>Without siphon</td>
</tr>
<tr>
<td>60</td>
<td>With Siphon</td>
</tr>
<tr>
<td></td>
<td>Without siphon</td>
</tr>
<tr>
<td>80</td>
<td>With Siphon</td>
</tr>
<tr>
<td></td>
<td>Without siphon</td>
</tr>
</tbody>
</table>

5- Irrigation application efficiency:
Values of irrigation application efficiency are shown in Table (5).
The average values of water application efficiency were estimated and found to be 69.16, 68.28 and 67.8% for A1, A2, and A3 treatments, respectively while for B1 and B2 were found to be 68.66 and 68.19%, respectively.

Table (5): Values of water stored, applied irrigation water and irrigation application efficiency as affected by the different treatments in 1997 season.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Water Stored (m³ Fed.)</th>
<th>Applied Irrigation Water (m³ Fed.)</th>
<th>Irrigation Application Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furrow length (m)</td>
<td>Method of Applied irrigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>With Siphon</td>
<td>2429.10</td>
<td>3500</td>
</tr>
<tr>
<td></td>
<td>Without siphon</td>
<td>2439.19</td>
<td>3539</td>
</tr>
<tr>
<td>60</td>
<td>With Siphon</td>
<td>2434.82</td>
<td>3562</td>
</tr>
<tr>
<td></td>
<td>Without siphon</td>
<td>2449.68</td>
<td>3592</td>
</tr>
<tr>
<td>80</td>
<td>With Siphon</td>
<td>2440.14</td>
<td>3577</td>
</tr>
<tr>
<td></td>
<td>Without siphon</td>
<td>2452.71</td>
<td>3637</td>
</tr>
</tbody>
</table>
6- Water use efficiently and utilization efficiency:

Values of water use and utilization efficiency as influenced by the different treatments are shown in Table (6). Generally it is noticed that the highest values of water use and utilization efficiency are accompanied with the highest values of cotton seed yield. The water utilization efficiency takes the same trend of crop water use efficiency, which the combination of A₁B₁ gave almost the highest value 0.39 and 0.30 Kg / m³ for crop water use and utilization efficiency, respectively. Similar trend was reported by El-Mowelhi et al. (1994).

7- Water distribution efficiency:

The obtained data of the water distribution efficiency were calculated and are presented also in Table (6).

Data showed that the water distribution efficiency increased as the furrow length decreased. On the other hand, the water distribution efficiency increased by using siphon tube method. The mean values of water distribution efficiency for the different furrow lengths were 95.75, 92.81 and 89.4% for furrow lengths of 40, 60, 80 meters long, respectively. Generally the present study indicated that the furrow length of 40 m and using siphon tube were found to be the best combination to obtain maximum cotton seed yield and also to save more water for other purposes.

Table (6): Crop water use efficiency, field water use efficiency and water distribution efficiency for cotton as affected by furrow length and method of applied irrigation water in 1997 Season.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Crop water Use Efficiency (Kg/m³)</th>
<th>Field Water use Efficiency (Kg/m³)</th>
<th>Water Distribution Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furrow length (m)</td>
<td>Method of Applied irrigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>With Siphon</td>
<td>0.39</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Without siphon</td>
<td>0.32</td>
<td>0.24</td>
</tr>
<tr>
<td>60</td>
<td>With Siphon</td>
<td>0.36</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>Without siphon</td>
<td>0.33</td>
<td>0.25</td>
</tr>
<tr>
<td>80</td>
<td>With Siphon</td>
<td>0.36</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>Without siphon</td>
<td>0.31</td>
<td>0.23</td>
</tr>
</tbody>
</table>

REFERENCES


Meleha, M.E.


تأثر طول الخط وطرق الرى الحقيقى على محصول القطن وكفاءة استخدام المياه
محمد إبراهيم مليحة
معهد بحوث إدارة المياه – المركز القومي لبحوث المياه – وزارة الموارد المائية والري

أجريت هذا البحث من خلال تجربة حقلية في الموسم الصيفي لعام 1997م بمحطة تجارب المقنعات المائية بالقرية – محافظة كفر الشيخ وذلك لقياس طول الخط وطرق الرى الحقيقى اضافة إلى الرى الرياحي، وتأثير ذلك على نتائج محصول القطن وكفاءة استخدام المياه

تم ذلك بدراسة ثلاث معاملات لطول الخط وهي: طول خط 40م، طول خط 60م، طول خط 80م وذلك بدراسة عاملتين لطرق اضافة الماء الرياحي، أحدهما باستخدام طريقة السيفون، والأخرى باستخدام طريقة السيفون، وكذلك دراسة طريقة السيفون في إضافة الماء للتربيه، وأيضاً دراسة طريقة السيفون باستخدام فرق معنوي في طول الخط (60، 40). وتلك الدراسة أظهرت أن إنتاج محصول النبات زاد بنسبة طول الخط باستخدام طريقة السيفون في إضافة الماء للتربيه

وجاءت النتائج على أن استخدام طريقة السيفون أدى إلى زيادة إنتاج محصول القطن، وبالتالي، فإن استخدام طريقة السيفون في إضافة الماء الرياحي، ينصح به، وذلك لزيادة الكفاءة في استخدام المياه.